Chapter 5
Coal Gasification

The domestic coal gasification industry presently consists of one facility that, as of September 1989, was the only commercial coal gasification plant in full operation in the United States[1] that reported generating two special mineral processing wastes: gasifier ash and process wastewater. The data included in this chapter are discussed in additional detail in a technical background document in the supporting public docket for this report.

5.1 Industry Overview

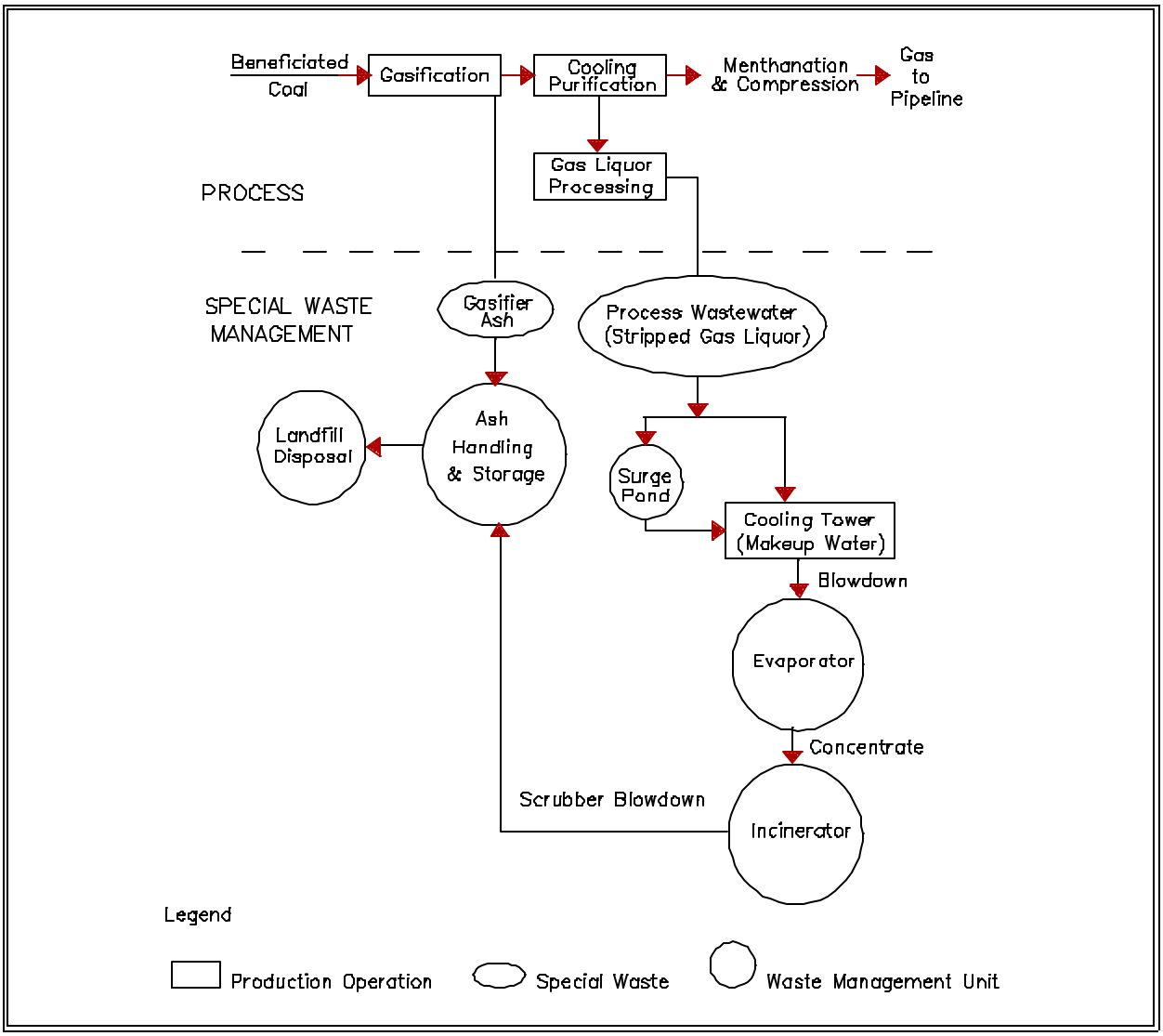
The coal gasification facility produces synthetic natural gas that is sent to a refinery for processing as a natural gas for energy production. The Great Plains Coal Gasification Plant is located in Beulah, Mercer County, North Dakota and is owned and operated by the Dakota Gasification Company. The Great Plains facility began operation in 1984. The facility reported an annual capacity of 1.1 million metric tons in 1988, and an actual production of 1.0 million metric tons of natural gas.

The Great Plains plant set a new annual production record for 1989 with a 9.8 percent increase over its 1988 level and a 5.1 percent increase over 1987 production.[2] The profitability of existing facilities and the potential for the opening of new plants will be affected by the prices of alternative fuel sources such as oil and gas.

[1] EPA is aware of two other facilities that conduct commercial-scale coal gasification operations. These plants, located at Daggett, California and Placamine, Louisiana, employ a different technology than that used at the Beulah, North Dakota facility that is the subject of this chapter. The facility in California has been inactive since early 1988 and is currently being overhauled so that it can burn a mixture of 75 percent coal and 25 percent sewage sludge. The Louisiana facility is currently operating and gasifies about 2,400 tons per day of coal. EPA is continuing to collect information on waste generation, management practices, and process operations at these facilities to determine if the regulatory determination will apply to any wastes generated by these facilities.

[2] "The Bulletin," 1990. Great Plains Synfuels-Dakota Gasification Company, Volume 7, No. 3, January 16, p. 4.

Exhibit 5-1
Coal Gasification



The facility employs 12 Lurgi Mark IV high pressure coal gasifiers, with two gasifiers on standby for spare capacity. The overall coal gasification process is illustrated in Exhibit 5-1. Lignite coal, which is taken from four mines that are co-located with the facility, is crushed and fed to the top of individual gasifiers through a lock-hopper system; steam and compressed oxygen are introduced at the bottom of each gasifier. As the coal charge descends through the gasifier bed, it is dried, devolatilized, and gasified. The ash remaining in the bed after the reaction is removed by a rotating grate at the bottom of the gasifier and is discharged through a gas lock. The ash is discharged into an enclosed ash sluiceway, where recirculating ash sluice water is introduced to cool the ash and transport it to the ash handling and disposal area. The hot crude product gas leaving the gasifiers goes through several operations, including quenching (to cool and clean), shift conversion (to alter the ratio of hydrogen to carbon monoxide), further cooling of the gas, and

processing through the Rectisol unit (to remove sulfur compounds and carbon dioxide). The desulfurized crude gas is sent to the methanation unit; the product gas is then compressed and dried for delivery to a pipeline for distribution.[3]

The quenching operation described above, in addition to cooling the raw gas, serves to remove entrained particles from the gas and to condense and remove unreacted steam, organic compounds, and soluble gases. The result of this cooling operation is an aqueous stream known as quench liquor. This process stream, along with similar streams from the shift conversion, gas cooling, and rectisol units, are sent to the gas liquor separation unit (for removal of tar and oil), to a phenosolvan unit (for phenol recovery), and to a phosam-W ammonia recovery unit (for ammonia recovery). The process water leaving the phosam-W unit, known as stripped gas liquor, is the special waste, coal gasification process wastewater. This process wastewater is used as make-up water for a water cooling system that is needed to cool the gasifiers during operation. The hot water is routed to a cooling tower used to remove heat from the system. The evaporation from the cooling tower exceeds the quantity of stripped gas liquor generated on an annual basis; hence, all stripped gas liquor is used as make-up water.

5.2 Waste Characteristics, Generation, and Current Management Practices

The coal gasification operation discussed in this report generates both a solid special mineral processing waste, gasifier ash, and an aqueous process waste, stripped gas liquor.

[3] Environmental Protection Agency, 1987. American Natural Gas Special Study. Prepared by CDM for the U.S. EPA, Washington, D.C., March, 1987; pp. 14-27.

Gasifier Ash

Gasifier ash, which reportedly has a particle size ranging from two millimeters to eight centimeters in diameter (gravel), is composed primarily of sulfate, calcium, silicon, sodium, aluminum, and magnesium. The Dakota gasification facility reported generating 245,000 metric tons of gasifier ash in 1989.

Using available data on the composition of coal gasification gasifier ash, EPA evaluated whether the ash exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on professional judgment and analyses of 59 gasifier ash samples from the Beulah facility, the Agency does not believe the ash is corrosive, reactive, ignitable, or EP toxic.

Gasifier ash that is removed from the bottom of the gasifier is quenched, passed through crushers to reduce the maximum size to eight centimeters, then sluiced into ash sumps for settling and dewatering. The dewatered ash is trucked to an on-site clay-lined landfill, where it is disposed along with ash from boilers, superheaters, and incinerators, and settled solids from process water management units (e.g., impoundments, API separators).

The landfill is 23 meters (75 feet) deep with an area of 4.9 hectares (12 acres) and is lined with recompacted clay. Although the landfill receives a variety of wastes, the ash accounts for approximately 95 percent of the total input. Material is typically not removed from the landfill and the remaining life is five years. A total of 1,500,000 metric tons[4] of combined solids has accumulated at the solid waste disposal site, approximately 95 percent of which is assumed to be gasifier ash based on Survey responses.

Process Wastewater

The process wastewater has an average pH of 9.8 and a solids content of approximately 0.2 percent. The principal contaminant in the water reportedly is NO_3, with additional trace amounts of chlorides, sodium, phenols, and oil and grease. The Dakota gasification facility reported generating 4.83 million metric tons of process wastewater during 1988.

Using available data on the composition of coal gasification process wastewater, EPA evaluated whether the wastewater exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on professional judgment and analyses of two process wastewater samples from the Beulah facility, the Agency does not believe the wastewater exhibits any of these characteristics. Using the EP leach test, for example, all of the inorganic constituents with EP toxicity regulatory levels, except selenium, were measured in concentrations that were at least two orders of magnitude below the regulatory level; the maximum observed concentration of selenium in EP leachate was 0.4 times the regulatory level.

The process wastewater (i.e., stripped gas liquor) is used as make-up water for the gasifier water-cooling system. In this system, large quantities of water are lost to evaporation (3,000-3,500 gpm, or 6-7 million metric tons per year) from the cooling tower. Evaporation losses are made up using primarily the stripped gas liquor, as well as softened ground water and other on-site wastewaters. Although the quantity of water lost from the gasifier cooling system through evaporation exceeds the quantity of process wastewater generated on an annual basis, the supply of process wastewater generated on a daily basis sometimes exceeds the need for cooling system make-up water. When this occurs, a surge pond is used to store the process wastewater until it is needed. This impoundment, which is lined with recompacted local clay and a 36 mil synthetic liner, has an area of about 4.3 hectares (11 acres) and a depth of 4 meters (13 feet). No long-term accumulation of waste occurs in this unit; the water is pumped to the cooling tower and settled solids are dredged (approximately 13 metric tons in 1988) and sent to the solid waste disposal landfill.

The evaporation of water from the cooling water system results in any impurities in the make-up water being concentrated in the remaining cooling system water; these impurities can lead to scaling or other operational problems in the system. Therefore, the cooling water in the system is bled off at a rate of 360-500 gpm to prevent concentration

[4] Quantity was originally reported in cubic yards (960,000 cubic yards). This was converted to metric tons assuming a specific gravity of 2.0 for the ash sludge.

of impurities from reaching unacceptable levels. This concentrated bleed, known as cooling tower blowdown, was generated at a rate of approximately 766,000 metric tons in 1988.

This cooling tower blowdown and the residuals from the treatment of the waste stream are not special wastes (because they are not large volume wastes), but the management of these streams is discussed briefly to provide an overview of the operation. The cooling tower blowdown is treated in a multiple effects evaporator (MEE) unit. Distillate from this treatment is returned to the cooling system or used as other facility utility water. The remaining residual, MEE concentrate, is returned as feed to the gasifier or is sent to an on-site liquid waste incinerator (LWI). Separate surge ponds are used for storage of MEE distillate and concentrate. The waste stream from the LWI unit, referred to as LWI blowdown, is sent to the coal ash sluice area to be included as make-up water for ash handling. Any incinerator ash/solids in the blowdown are, therefore, combined with the gasifier ash and managed as such.[5]

5.3 Potential and Documented Danger to Human Health and the Environment

This section addresses two of the study factors required by §8002(p) of RCRA: (1) potential danger (i.e., risk) to human health and the environment; and (2) documented cases in which danger to human health or the environment has been proven. Overall conclusions about the hazards associated with coal gasifier ash and process wastewater are provided after these two study factors are discussed.

5.3.1 Risks Associated with Gasifier Ash and Process Wastewater

Any potential danger to human health and the environment from coal gasifier ash and process wastewater depends on the presence of toxic constituents in the wastes that may pose a risk and the potential for exposure to these constituents.

Constituents of Potential Concern for Coal Gasification Gasifier Ash

EPA identified chemical and radiological constituents in coal gasifier ash that may present a hazard by collecting data on the composition of the waste and evaluating the intrinsic hazard of the ash's constituents.

Data on Coal Gasifier Ash Composition

EPA's characterization of the gasifier ash and its leachate is based on data from a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW) and industry responses to a RCRA §3007 request in 1989. These data provide information on the concentrations of 20 metals, radium-226, uranium-238, gross alpha and beta radiation, cyanide, a number of other inorganic constituents (i.e., phosphate, fluoride, and sulfate), and 30 semivolatile and volatile organic constituents in total and leach test analyses.

Concentrations in total samples of the ash are consistent for most constituents across the two data sources. Likewise, concentrations from leach test analyses of the gasifier ash generally are consistent across the two data sources. Among EP results, however, arsenic, barium, chromium, and silver concentrations vary by more than two orders of magnitude. In addition, maximum leachate concentrations of many constituents (i.e., arsenic, barium, cadmium, chromium, copper, lead, manganese, selenium, and silver) detected in EP leach tests are approximately 10 times higher than concentrations detected by SPLP or TCLP analyses. Conversely, concentrations of aluminum, iron, uranium-238, and vanadium detected by SPLP analyses are greater than approximately five times the highest EP and TCLP concentrations.

[5] As reported by Dakota Gasification Company, approximately 32,000 metric tons of LWI blowdown was generated in 1988 with a solids content of 5 percent; these approximately 1,600 metric tons of solids are assumed to be included in the total volume of gasifier ash reported by the company.

Process for Identifying Constituents of Potential Concern

As discussed in Section 2.2.2, the Agency evaluated the waste composition data summarized above to determine if coal gasifier ash contains any chemical constituents that could pose an intrinsic hazard, and to narrow the focus of the risk assessment. The Agency performed this evaluation by first comparing constituent concentrations to the screening criteria, and then by evaluating the environmental persistence and mobility of constituents that are present in concentrations that exceed the criteria. These screening criteria were developed using assumed scenarios that are likely to overestimate the extent to which constituents in the wastes are released to the environment and migrate to possible exposure points. As a result, this process eliminates from further consideration those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic organisms, and air and water resources (see Exhibit 2-3). Given the conservative (i.e., overly protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the waste in greater detail.

Identified Constituents of Potential Concern

Exhibits 5-2 and 5-3 present the results of the comparisons for gasifier ash total analyses and leach test

Exhibit 5-3
Potential Constituents of Concern In Coal Gas Ash Leachate[a]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[b]	No. of Analyses Exceeding Criteria/No. of Analyses for Constituent
Arsenic	35 / 59	Human Health* Resource Damage Aquatic Ecological	35 / 59 4 / 59 2 / 59
Lead	27 / 59	Human Health Resource Damage Aquatic Ecological	10 / 59 27 / 59 5 / 59
Silver	7 / 58	Human Health Resource Damage Aquatic Ecological	1 / 58 1 / 58 7 / 58
Selenium	19 / 59	Resource Damage Aquatic Ecological	2 / 59 2 / 59
Mercury	7 / 59	Aquatic Ecological	5 / 59
Chromium	10 / 59	Resource Damage Aquatic Ecological	1 / 59 1 / 59
Sulfate[c]	1 / 1	Resource Damage	1 / 1
Aluminum[c]	2 / 2	Aquatic Ecological	2 / 2

Potential Constituents of Concern In Coal Gas Ash Solids[a]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[b]	No. of Analyses Exceeding Criteria/No. of Analyses for Constituent
Molybdenum	3 / 3	Resource Damage	3 / 3
Barium	49 / 59	Resource Damage	21 / 59
Uranium-238	1 / 1	Inhalation* Radiation*[c]	1 / 1 1 / 1
Thallium	3 / 3	Ingestion	2 / 3
Arsenic	3 / 5	Ingestion Inhalation	3 / 5 3 / 5
Chromium	4 / 4	Inhalation	1 / 4

(a) Constituents listed in this table are present in at least one sample at a concentration that exceeds a relevant screening criterion. The screening criteria values are shown in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. Unless otherwise noted, the constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on $1x10^{-5}$ lifetime cancer risk; others are based on noncancer effects.

(c) Data for this constituent are from SPLP test results.

(a) Constituents listed in this table are present in at least one sample at a concentration that exceeds a relevant screening criterion. The screening criteria values are shown in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a $1x10^{-5}$ lifetime cancer risk; others are based on noncancer effects.

(c) Includes direct radiation from contaminated land and inhalation of radon decay products.

analyses, respectively, to the screening criteria. These exhibits list all constituents for which sample concentrations exceed a relevant screening criterion.

Of the 58 constituents analyzed in the ash solids, only uranium-238, thallium, arsenic, and chromium concentrations exceed the screening criteria. Among these constituents, uranium-238, thallium, and arsenic exceed the screening criteria with greater frequency and magnitude. However, only arsenic is present at a concentration that exceeds a screening criterion by a factor of more than 10. These exceedances of the screening criteria indicate the potential for a variety of impacts, as follows:

- Uranium-238 concentrations exceed the radiation screening criterion by a factor of almost 4, suggesting that the ash could pose an unacceptable radiation risk if the ash were used in an unrestricted manner (e.g., direct radiation doses and doses from the inhalation of radon could be unacceptably high if people were allowed to build homes on top of the ash or if the ash were used for construction purposes).
- Uranium-238, arsenic, and chromium concentrations in the ash may be present in concentrations that exceed the inhalation screening criteria. This suggests that if small particles from the ash are blown into the air in a high concentration (equal to the National Ambient Air Quality Standard for particulate matter), chronic inhalation of these constituents could cause a cancer risk exceeding 10^{-5}. As discussed in the section on release/transport/exposure potential, however, such large exposures to windblown particles are generally not expected at the Beulah facility.
- Thallium and arsenic may be present in the ash at concentrations that exceed the incidental ingestion screening criterion, suggesting that these constituents could pose health risks if small quantities of the ash are routinely ingested over a long period of time (i.e., more than about seven years). Arsenic concentrations could pose a cancer risk of greater than $1x10^{-5}$, while thallium concentrations could cause adverse central nervous system effects.

Of the 24 constituents analyzed in the leach tests, the following 10 constituents are present at concentrations that exceed the screening criteria based on water pathway risks: arsenic, lead, silver, selenium, mercury, chromium, sulfate, aluminum, molybdenum, and barium. All of these constituents are inorganics that do not degrade in the environment. Arsenic, silver, and lead are of relatively greater concern because their concentrations in the ash leachate exceed the screening criteria with the greatest frequency and magnitude. Arsenic concentrations exceeded the human health (drinking water) screening criterion in almost 60 percent of the samples analyzed; the median arsenic concentration exceeded the criterion by a factor of 8, and the maximum exceeded by a factor of 1,100. Silver concentrations exceeded the aquatic ecological screening criterion in 12 percent of the samples, and the maximum silver concentration exceeded the criterion by a factor of 370. No other constituents are present in concentrations that exceed screening criteria by a factor of 10. In addition, no constituents were detected in concentrations that exceed the EP toxicity regulatory levels.

These exceedances of the screening criteria indicate the potential for the following types of effects under the following conditions:

- If leachate from the ash were released to ground or surface water, and diluted less than tenfold during migration to a drinking water source, long-term chronic ingestion may cause adverse health effects due to the presence of arsenic, lead, and silver. The arsenic concentrations in the diluted ash leachate may pose a significant (i.e., $>1x10^{-5}$) lifetime cancer risk if ingested.
- Coal gasifier ash leachate contains arsenic, lead, silver, selenium, chromium, sulfate, molybdenum, and barium in concentrations that exceed the water resource damage screening criteria. This suggests that if leachate from the ash is released and migrates into ground or surface water with a tenfold dilution or less, the resulting concentrations of these constituents may be sufficient to restrict the potential future uses of the affected water (e.g., render stream water unsuitable for irrigation or for drinking water supply unless treated).
- Arsenic, lead, silver, selenium, mercury, chromium, and aluminum concentrations in the ash leachate exceed the aquatic ecological screening criteria, suggesting that these constituents may present a threat to aquatic ecological receptors if the leachate migrates (with less than 100-fold dilution) to streams, rivers, or lakes.

These exceedances of the screening criteria, by themselves, do not demonstrate that the ash poses a significant risk, but rather indicate that it may present a hazard under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for the ash to cause significant impacts, EPA analyzed the actual conditions that exist at the sole facility that generates and manages the waste (see the following section on release, transport, and exposure potential).

Coal Gasification Process Wastewater Constituents of Potential Concern

Using the same process summarized above for gasifier ash, EPA identified constituents in coal gasification process wastewater that may present a hazard by collecting data on the composition of this waste, and evaluating the intrinsic hazard of the chemical constituents present in the process wastewater.

Data on Coal Gasification Process Wastewater Composition

EPA's characterization of the process wastewater and its leachate is based on data from a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW) and industry responses to a RCRA §3007 request in 1989. These data provide information on the concentrations of 20 metals, a number of other inorganic constituents (i.e., ammonia, ortho-phosphate, and phosphorus), and 159 organic constituents in total and leach test analyses.

Concentrations in total sample analyses of the process wastewater are consistent for most constituents across the two data sources. For antimony, however, the results differ significantly. EPA did not detect antimony in the wastewater at a detection limit of 0.025 mg/L while industry data show antimony to be present at concentrations almost five orders of magnitude higher. Concentrations from the two types of leach test analyses (i.e., EP and SPLP) of the process wastewater generally are similar. However, EP leach test data from the two sources -- 1989 OSW sampling and analysis and industry response to the RCRA §3007 request -- differ considerably (no SPLP data were provided by industry). Among the eight constituents for which EP leach test data are available from EPA and industry, four constituents (i.e., arsenic, chromium, mercury, and selenium) are detected in EPA analyses at concentrations that are one or two orders of magnitude higher than in industry analyses.

The following evaluation of constituents in the process wastewater is based on concentrations detected in total analyses of the wastewater. Leach test analyses are generally similar to total analysis results, although a smaller number of constituents in concentrations above the screening criteria are identified in the leachate (possibly because of the filtration step involved in leach test analyses). Several of the inorganic constituents with EP toxicity regulatory levels (arsenic, cadmium, chromium, lead, mercury, and selenium) were measured in higher concentrations in total analyses than leach test analyses.

Identified Constituents of Concern

Exhibit 5-4
Potential Constituents of Concern In Coal Gas Process Wastewater (total)[a]

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria[b]	No. of Analyses Exceeding Criteria/No. of Analyses for Constituent
Phosphorous	1/1	Aquatic Ecological	2/2
Phosphate	1/1	Aquatic Ecological	1/1
Antimony	2/3	Human Health Resource Damage Aquatic Ecological	2/3 2/3 2/3
Mercury	5/6	Resource Damage Aquatic Ecological	1/6 5/6
Arsenic	3/8	Human Health* Resource Damage	3/8 2/8
Thallium	2/3	Human Health	2/3
Molybdenum	2/3	Resource Damage	2/3
Selenium	5/8	Resource Damage Aquatic Ecological	5/8 1/8
Nickel	2/3	Human Health Resource Damage Aquatic Ecological	1/3 1/3 2/3
Iron	3/3	Resource Damage	2/3
Copper	3/3	Aquatic Ecological	2/3
Manganese	3/3	Resource Damage	1/3
Cobalt	2/3	Resource Damage	1/3
Lead	2/8	Human Health Resource Damage Aquatic Ecological	1/8 2/8 1/8
Cadmium	2/8	Human Health Resource Damage Aquatic Ecological	1/8 1/8 1/8
Chromium	9/10	Resource Damage	1/10
Acetonitrile	2/2	Human Health	2/2
Phenol	2/2	Resource Damage	2/2
pH	1/1	Resource Damage	1/1

(a) Constituents listed in this table are present in at least one sample at a concentration that exceeds a relevant screening criterion. The screening criteria values are shown in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "*" are based on $1x10^{-5}$ lifetime cancer risk; others are based on noncancer effects.

Exhibit 5-4 presents the results of the comparisons of coal gasification process wastewater constituent concentrations to the screening criteria. This exhibit lists all constituents for which at least one sample concentration exceeds a relevant screening criterion.

Of the 182 constituents analyzed in the process wastewater, only 19 are present at concentrations that exceed the screening criteria: phosphorus, phosphate, antimony, mercury, arsenic, thallium, molybdenum, selenium, nickel, iron, copper, manganese, lead, cadmium, cobalt, chromium, acetonitrile, phenol, and pH. Seven of these -- phosphorus, phosphate, antimony, mercury, arsenic, thallium, and phenol -- were present in concentrations in the process wastewater that exceed the screening criteria with greatest frequency and magnitude (i.e., maximum concentrations of these constituents exceed a screening criterion by more than a factor of 10, and more than one-third of all samples analyzed for the constituent exceed the criterion). None of the constituents, however, were detected in concentrations above the EP toxicity regulatory levels, and the wastewater does not exhibit the hazardous waste characteristics of corrosivity, ignitability, or reactivity.

These exceedances of the screening criteria have the following implications:

- Antimony, arsenic, thallium, acetonitrile, nickel, lead, and cadmium may be present in seepage from the process wastewater surge pond at concentrations that exceed the human health screening criteria. This suggests that if the wastewater is released to useable ground or surface water, these constituents could cause adverse human health effects via long-term chronic ingestion of drinking water, if it is diluted by only a factor of 10 during migration to drinking water supplies. Exposures to arsenic in the diluted leachate could pose a lifetime cancer risk of greater than $1x10^{-5}$.
- Phenol, antimony, mercury, arsenic, molybdenum, selenium, nickel, iron, manganese, lead, cadmium, cobalt, and chromium are present in the process wastewater at concentrations that exceed the water resource damage screening criteria. This indicates that if the wastewater migrates into ground water with less than a 10-fold dilution or migrates into surface water with less than a 100-fold dilution, the resulting concentrations of these contaminants could render the water resources unsuitable for a variety of uses (e.g., drinking water, livestock watering, irrigation, consumption of fish that live in contaminated water bodies). The wastewater is also alkaline (pH 10) and could threaten water resources if it were to raise the pH of receiving waters to above 8.5 standard units.
- If process wastewater were released to nearby surface waters (with less than 100-fold dilution), phosphorus, phosphate, antimony, mercury, selenium, nickel, copper, lead, and cadmium could pose a risk to aquatic life.

As discussed above for coal gas ash, these exceedances of the screening criteria, by themselves, do not demonstrate that the process wastewater poses a significant risk, but rather indicate that the wastewater may present a hazard under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for the wastewater to cause significant impacts, EPA proceeded to the next step of the risk assessment to analyze the actual conditions that exist at the facility that generates and manages the waste.

Release, Transport, and Exposure Potential

This section describes the actual release, transport, and exposure potential of the coal gasification wastes as they were generated and managed at the Beulah plant in 1988. For this analysis, the Agency did not assess the hazards of off-site use or disposal of the wastes, because the wastes are currently managed only on-site (although it is conceivable that ash with certain properties could be used off-site in the future in the manufacture of cement or concrete products). In addition, the following analysis does not consider the risks associated with variations in waste management practices or potentially exposed populations in the future because of a lack of data on which to base forecasts of future conditions. Alternative practices for the management of gasifier ash and process wastewater are discussed in Section 5.5.

Ground-Water Release, Transport, and Exposure Potential

The waste characterization data discussed above indicate that leachate from the waste ash contains 10 constituents at concentrations that exceed the conservative screening criteria. Similarly, the characterization of the process wastewater identified 19 constituents that exceed the screening criteria. These wastes contain from 2 to 7 constituents that exceed screening criteria related to ground water by factors of at least 10, although no contaminants were detected in concentrations that exceed the EP toxicity regulatory levels. The constituents in the waste ash leachate and process wastewater that are expected to be readily mobile in groundwater are phosphorus, phosphate, mercury, molybdenum, selenium, cadmium, chromium, and sulfate.

Differences in the characteristics of the management units used to dispose of the gasifier ash and store process wastewater contribute to substantial differences in the potential ground-water hazards posed by these wastes as they are currently managed.

- The gasifier ash landfill has a liner of recompacted local clay, but does not have any other type of ground-water controls such as a leachate collection system.
- The surge pond that is used to temporarily store the process wastewater has multiple engineered controls to limit seepage to ground water. This pond has a double liner -- comprised of separate layers of synthetic material and recompacted local clay -- and has both primary and secondary leachate collection systems.

As a consequence of these controls, the potential for releases of process wastewater from the surge pond is limited to a large extent, while the potential for releases from the landfill is higher. In fact, ground-water monitoring data from the Dakota facility provides evidence that the ash landfill may be contributing to ground-water degradation. The Dakota facility reported that drinking water standards for nitrate, sulfate, chloride, pH, and total dissolved solids had been exceeded in downgradient monitoring wells. The facility attributes these exceedances to possible ambient ground-water quality problems in this area; Section 5.3.2 provides further discussion of these monitoring data.

The hydrogeologic characteristics at the site indicate a potential for contaminants to migrate into ground water: net recharge in the vicinity of the facility is moderate (10 cm/year), and ground water is very shallow (0.3 to 0.6 meters beneath the landfill). These factors, in combination with the relatively high leachability of the ash and the limited ground-water release controls at the landfill indicate a high potential for contaminants to migrate from the ash landfill into underlying ground water. The controls on the surge pond should significantly limit migration of the wastewater.

Although the facility reported that the aquifer underlying the facility is not being used for any purpose, mapping data indicate that there are two residences between 900 and 1,600 meters (1 mile) downgradient of the facility that appear to be located outside of areas covered by local water distribution systems, and, therefore, may rely on private water sources (e.g., private wells). Consequently, leachate from the landfill could damage the value of the aquifer as a potential resource, but the potential for current human exposures is low because of the large distance (> 900 meters) to the small population (i.e., two residences) that may rely on ground water downgradient of the site as a drinking water supply.

Surface Water Release, Transport, and Exposure Potential

In theory, constituents from the gasifier ash in the landfill or process wastewater in the surge pond could enter surface waters by (1) migration of leachate or seepage through ground water that discharges to surface water or (2) direct overland run-off of dissolved or suspended materials from the landfill or surge pond.

The potential for release and transport of gasifier ash and process wastewater contaminants to surface water appears limited by the relatively low precipitation in the area (37 cm/year), the presence of stormwater run-off controls designed to limit erosion from the landfill and overflow of the surge pond, and the gentle topographic slope (0 to 2 percent) that also limits erosion potential. In addition, while there is an on-site stormwater diversion ditch and a nearby intermittent stream, the facility is far removed from perennial water bodies that may be used: the nearest perennial stream is 10 km (6 miles) downslope and this stream discharges into the Knife River approximately 15 km away. Because the facility is not located in or near a 100-year floodplain, large episodic releases and subsequent overland transport due to flooding are also unlikely.

Despite these mitigating factors, releases to surface water from the ash landfill may have occurred. As discussed in Section 5.3.2, a State of North Dakota Notice of Violation indicates that gasifier ash management practices at this facility "probably resulted in some surface water degradation."[6] Although the notice does not clarify this statement, the degradation is likely confined to the on-site drainage ditch and nearby intermittent stream, potentially caused by either stormwater run-off or discharge of contaminated ground water from the landfill. These waters are

[6] North Dakota State Department of Health and Consolidated Laboratories. 1987. Interdepartmental Memorandum from S. Tillotson to B. Dellmore, through M. Schock, Re: ANG Notice of Violation. 7/20/87.

unlikely to be used for human consumption, but any contamination in them potentially could be harmful to aquatic organisms.

Should contamination from this site reach the distant Knife River or its tributary, either by overland run-off or through ground-water infiltration, the relatively large annual average flow (600 mgd) of the river could rapidly assimilate (dilute) the contamination. Consequently, contamination from gasifier ash and process wastewater appear to pose a minimal threat to potential uses of the river or to its aquatic life. To the best of the Agency's knowledge, no population currently relies on the river as a regular drinking water source in the vicinity of the Dakota facility, and no current human health risks from drinking water exposures are expected.

Air Release, Transport, and Exposure Potential

Air pathway risks from ash and process wastewater involve two different release pathways. The constituents that exceed the screening criteria in gasifier ash -- uranium-238, arsenic, and chromium -- are nonvolatile inorganics that can be released to air only as wind-blown particles (dust). Acetonitrile and phenol conceivably could pose inhalation risks through volatilization from the process wastewater. The concentrations of these constituents in the wastes represent relatively low human health risks (as indicated by relatively low ratios of the maximum concentrations to screening criteria).

Factors that determine the potential for inorganic constituents of the gasifier ash to be suspended in air are the particle size of the ash, the exposed surface area of the landfill, the moisture content of the ash, the use of dust suppression controls, and wind speeds in the vicinity of the facility. The potential for exposure to airborne contaminants depends on the distances from the landfill to nearby residences and the population in the area. In general, particles that are $\leq$ 100 micrometers (µm) in diameter are wind suspendable and transportable. Within this range, however, only particles that are $\leq$ 30 µm in diameter can be transported for considerable distances downwind, and only particles that are $\leq$ 10 µm in diameter are respirable.

Although some fraction of the ash may exist as particles that can be suspended in air and cause airborne exposure and related impacts, the vast majority of the gasifier ash is comprised of particles too large to be suspended, transported, and respired. In addition to the generally large particle size, releases of the ash are also limited by dust suppression practices and the moisture content of the ash as it is deposited in the landfill. However, in the event that areas of the landfill surface become dry (e.g., if dust suppression is ceased or provides incomplete coverage), a small fraction of the ash particles could be blown into the air because of the large exposed area (approximately 5 hectares [12 acres]), the relatively small number of days with rain that may suppress dust (54 days/yr), and the strong winds in the area (4.5 to 6.7 m/s). After the small, near-surface particles are depleted, airborne emissions would again decline to low levels.

The ability of an organic constituent to volatilize from the wastewater depends on its Henry's Law constant, which is a measure of the constituent's tendency to partition between water and air. A large Henry's Law constant indicates a greater propensity for an organic compound to volatilize from water. Because acetonitrile and phenol have relatively high Henry's Law constants, they may be released from the surge pond by volatilization.

Evaluation of the location of potential exposure points indicates that the air pathway risks from these wastes are relatively small. Winds at the Dakota facility blow most frequently in the WNW, W, S, WSW directions. The nearest downwind residences in these directions are quite distant (i.e., 2.1, 1.5, 4.5, and 5.2 km, respectively) and the population within 8 kilometers (5 miles) in these directions is very sparse (i.e., 13, 18, 8, 18 people, respectively). The population within a radius of 80 km from the facility is approximately 40,000. Considering the low inorganic constituent concentrations relative to air pathway screening criteria, the low potential for release of dust from the landfill, and the great dispersion of airborne contaminants (both volatiles and particles) that would occur during transport to exposure points greater than one kilometer away, there is a low potential for human exposure (and associated health risk) to dust blown from the ash landfill or contaminants volatilized from the surge pond.

Proximity to Sensitive Environments

The coal gasification facility is not located in or near any environments that may facilitate contaminant release and transport (such as floodplains, karst, and fault zones), that have high resource value (such as National Parks), or environments that are especially sensitive to contaminant exposures (such as wetlands and endangered species habitat).

Risk Modeling Results

Based upon the evaluation of the intrinsic hazard of gasifier ash and process wastewater, both wastes contain a number of constituents in concentrations that may present a hazard under a very conservative set of hypothetical release and exposure conditions. However, considering the actual conditions that exist at the Beulah, ND facility, the potential for these wastes to cause significant human health or environmental impacts is low. This conclusion is based on the following findings:

- Only arsenic and silver in coal gasifier ash and its leachate are present at concentrations more than ten times the screening criteria; seven constituents in coal gas process wastewater exceed the conservative screening criteria by a factor of 10 or greater; but neither gasifier ash nor process wastewater exhibit any of the four characteristics of hazardous waste.
- The potential for releases from the ash landfill and surge pond are limited by controls such as liners, run-off controls, and dust suppression. Nevertheless, releases to ground- and surface water from the ash landfill have occurred. The potential for exposures to released contaminants at concentrations of concern is relatively low given the large distances to nearby residences and perennially flowing surface water.

This conclusion is supported by the information on documented damage cases (presented in the next section) and the Agency's risk modeling results for other wastes that appear to pose a greater hazard than the coal gasification wastes. Therefore, in accordance with the risk assessment methodology outlined in Chapter 2, the Agency has not conducted a quantitative risk modeling exercise for these wastes. Section 5.3.3 below discusses the basis for the assessment of moderate hazard in more detail.

5.3.2 Damage Cases

State and EPA regional files were reviewed in an effort to document the performance of waste management practices for gasifier ash and process wastewater at Dakota Gasification's active facility in Beulah, North Dakota, and at two inactive coal gasification facilities: Ashland in South Point, Ohio; and Fairfield in Fairfield, Iowa.[7] The file reviews were combined with interviews with State and EPA regional regulatory staff. Through these case studies, EPA found documented environmental damages associated with the gasifier ash management units at the Dakota Gasification facility.

Dakota Gasification Company, Beulah, North Dakota

The plant site is located on a broad valley that is underlain by the Antelope Valley or Beulah Trench aquifer. The Beulah Trench interconnects with the aquifer associated with the Knife River Valley, which serves as a water supply source for the communities of Beulah and Hazen, located approximately nine miles south and 14 miles southeast of the plant site, respectively. The mine used as the coal supply for the plant is located immediately east of the facility site.[8]

As described earlier in this chapter, ash from the gasifier is quenched (with blowdown from the wet scrubber system on the facility's incinerator) and sluiced into one of four ash sumps where the ash is settled from the slurry. The liquid recovered during the ash dewatering is recycled back to the ash quench and sluicing area or used as makeup water to the liquid waste incinerator. The dewatered ash is trucked to an on-site landfill.

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[7] Facilities are considered inactive for purposes of this report if they are not currently engaged in primary mineral processing.

[8] North Dakota State Department of Health and Consolidated Laboratories (NDSDHCL). 1989. Letter from S. Tillotson to C. Greathouse, Re: Dakota DGC SU-101. December 21.

The landfill area designated as SU-101 is currently the active portion of the landfill that receives gasifier ash. Large pits within the SU-101 area are utilized for the disposal of the gasifier ash and other waste streams. According to the North Dakota State Department of Health and Consolidated Laboratories (NDSDHCL), at least 90 percent of all waste disposed in SU-101 consists of gasifier ash. Excess liquids from the gasifier ash disposed in area SU-101 flows with any additional run-off to the adjacent sumps and may be later pumped to the evaporation pond. Analytical data from August 1989 show that the pH of water in the sump ranges from 12.7 to 13.7, while the arsenic concentration ranges from 13.8 mg/L to 22.0 mg/L, and the selenium concentration ranges from 1.1 mg/L to 2.2 mg/L.[9,10,11]

In December 1985, NDSDHCL expressed concerns to ANG (the former owner of the facility) regarding the levels of water in the run-off pond [sump] within the ash storage area, because of high pH and high arsenic content in the run-off water. The Department stated that the disposal of gas ash containing excess liquids must be discontinued immediately.[12]

In July 1987, NDSDHCL Division of Waste Management and Special Studies prepared a memorandum that summarizes letters written and inspections conducted relating to ANG's gasifier ash dewatering system and disposal area. This memorandum requested the issuance of a Notice of Violation to ANG for improper waste handling procedures relating specifically to the dewatering of gasifier ash, the unauthorized placement of associated liquids and sludges having potentially hazardous characteristics in the gasifier ash disposal area, and the spillage of ash, liquids and sludges during transport from the dewatering area to the ash disposal area. The memorandum discusses ANG's violations of the State's Solid Waste Management rules, including the unauthorized placement of liquid and semi-liquid wastes in a landfill not permitted for such wastes, the unauthorized improper construction and operation of the disposal site, the inadequate protection of surface water in violation of permit conditions, and the spillage of liquids, sludges, and ash during transport. As stated in the memorandum: "ANG's [practices have] . . . increased the potential for groundwater degradation and [have] probably resulted in some surface water degradation."[13]

According to the NDSDHCL, Dakota Gasification discontinued the use of unlined ponds for the disposal and storage of liquid bearing wastes in 1988. Ponds since mid-1988 have at least a clay liner. The most recently completed pond has a composite liner. The state also noted that although the liquid bearing wastes are still being disposed into a clay lined landfill, excessive run-off is directed into a pond with a composite liner.[14]

According to monitoring reports submitted by DGC to NDSDHCL presenting quarterly data from April 1988 to June 1989, monitoring wells around a portion of the landfill area indicated significant differences in downgradient wells as compared to upgradient wells. From five to six total samples taken from upgradient wells 15, 16, and 17, Electrical Conductivity (EC) averaged 4,790 µmhos/cm; sulfates (SO_4) averaged 1,248 mg/L; and total dissolved solids (TDS) averaged 3,638 mg/L. From eight total samples taken from downgradient wells, 14, 18 and 24, EC averaged 11,870 µmhos/cm; SO4 averaged 7,056 mg/L; and TDS averaged 11,569 mg/L.

Monitoring well analytical data in a DGC report dated February 22, 1989, indicated that three additional wells near the ash disposal area had exhibited "increased concentrations" of some constituents. Analysis of samples from one of these wells revealed increased mean specific conductance (15,000 Omhos/cm), as well as increased mean concentrations of sodium (3,000 mg/L), sulfates (11,000 mg/L), and TDS (17,000 mg/L). Background, or upgradient data, were not provided. The other two wells contained similar concentrations, and over a period of one year or less, historical

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[9] NDSDHCL. 1990. Personal Communication with S. Tillotson. January.

[10] Dakota Gasification Company. 1989. Letter from D.R. Guminski, Environmental Manager, to M. Shock, NDSDH. November 17.

[11] NDSDHCL. 1990. Letter from S. Tillotson to C. Greathouse, Re: DGC SU-101. February 20.

[12] NDSDHCL. 1985. Letter from M. Schock to G. Weinreich, ANG, Re: SU-049. With Attachments. December 12.

[13] NDSHDCL. 1987. Interdepartmental Memorandum from S. Tillotson to B. Dellmore, through M. Schock, Re: ANG Notice of Violation. July 20.

[14] NDSDHCL. 1990. Letter from S. Tillotson to K. McCarthy, ICF, Re: Dakota Gasification Company SU-101. May.

data document the increases in these constituent levels (Exhibit 5-5).[15]

5.3.3 Findings Concerning the Hazards of Coal Gasification Wastes

Based upon the detailed examination of the inherent characteristics of coal gasifier ash and process wastewater, the management practices that are applied to these wastes, the environmental setting in which the materials are managed, and the documented environmental damages that have been described above, EPA concludes that these wastes pose a low risk to human health and the environment.

Intrinsic Hazard of the Wastes

Review of the available data on constituent concentrations in gasifier ash and its leachate indicates that only arsenic and silver exceed one or more of the screening criteria by more than a factor of 10, though maximum concentrations of these two constituents exceed the screening criteria by a wide margin (1,100 in the case of arsenic and 370 in the case of silver). Based on one sample result, the concentration of uranium-238 exceeds the radiation screening criterion by almost a factor of four, suggesting that uranium and its decay products could pose an unacceptable radiation risk if the ash were used in an unrestricted manner. Combined with the fact that the ash does not exhibit any of the four hazardous waste characteristics, these findings lead EPA to conclude that the intrinsic hazard of this waste is low to moderate. These data also suggest that the documented ground-water contamination described above in Section 5.3.2, was caused, at least in part, by wastes other than gasifier ash that had been co-disposed in the ash landfill.

Exhibit 5-5
Increases in Concentrations of Selected Constituents in Two Gasifier Ash Disposal Area Monitoring Wells (1987 - 1988)

Well	Net Increase in Parameter Value Between Sampling Periods				
	Cl (mg/L)	SO_4 (mg/L)	Na (mg/L)	Spec. Cond. (µmhos/cm)	TDS (mg/L)
W04018	3,910	840	1,125	11,290	---
W04020	2,114	525	877	5,200	3,759

[15] Dakota Gasification Company. 1989. Letter from A.C. Lukes to S. Tillotson, NDSDH, Re: Ground-water Monitoring Assessment Plan--SU-049. February 22.

Review of the available data on process wastewater constituent concentrations indicates that 19 constituents exceed one or more of the screening criteria and that seven exceed the criteria by more than a factor of 10. The available data also indicate that the waste does not exhibit any of the four hazardous waste characteristics. As a result, EPA believes that the intrinsic hazard of this waste is moderate.

Potential and Documented Dangers

Evaluation of the potential for release, transport, and exposure through the ground-water, surface water, and air pathways indicates that potential releases of contaminants in the process wastewater are limited by engineered release controls, and that improper construction and waste handling at the ash landfill has caused past releases to ground- and surface water. Nevertheless, the potential for current exposures to any released contaminants is low because of the relatively large distance from waste management units to potential exposure points.

Releases to ground water from the surge pond are unlikely because this unit is double-lined and has two leachate collection systems. In contrast, the documented case of danger to human health and the environment indicates that the design and operation of the ash landfill do not control the release of coal gasifier ash or other contaminants to ground water. Any ground-water contamination arising from the ash landfill at present, however, is unlikely to threaten human health or ground-water use given the relatively low levels of contamination in ash leachate, the current lack of use of ground water in the area, and the relatively large distance to existing downgradient residents where exposures could occur.

Releases from the process wastewater surge pond to surface water via ground-water discharge are limited by the ground-water controls mentioned above, and overland flow of surge pond overflow is limited by run-off controls. The damage case indicates that surface water degradation may have occurred due to ash management practices, but it is unlikely that contamination from the ash would pose significant threats to the Knife River or its tributaries given the large distance to the river and its perennial tributaries and the large flow of the river. Residual contamination in a drainage ditch and nearby intermittent stream, however, may adversely affect aquatic organisms living in these habitats.

Releases to air are limited by dust suppression at the landfill. In addition, any contaminants released in windblown ash or volatilized from the surge pond would pose a small risk because of the large distance (> 1 km) to the nearest residence in a predominant wind direction.

Conclusions

Based on the low to moderate degree of intrinsic hazard of the wastes, the limited potential for release, transport, and exposure via the ground-water, surface water, and air pathways, and the limited evidence of documented cases of danger to human health or the environment from current waste management practices, EPA concludes that the potential danger posed by coal gasifier ash and process wastewater from coal gasification is limited. Accordingly, the Agency has investigated current applicable regulatory requirements and alternative waste management and utilization, but has not examined in detail the costs and associated impacts of additional regulatory requirements.

5.4 Existing Federal and State Waste Management Controls

5.4.1 Federal Regulation

EPA is unaware of any specific Federal management control or pollutant release requirements that apply specifically to coal gasifier ash or process wastewater from coal gasification.

5.4.2 State Regulation

The single coal gasification facility addressed by this report is located in Beulah, North Dakota. The State of North Dakota excludes mineral processing wastes from its hazardous waste regulations, but classifies the coal gasification wastes generated at the Beulah facility as "special wastes" under the state's solid waste regulations. Under this approach, North Dakota currently regulates the disposal of gasifier ash by requiring that the landfill into which the ash is placed be permitted. Permit requirements include standards for liners, closure, and post-closure care. Unlike the landfill requirements, North Dakota has not required that the process wastewater pond at this facility be permitted. The state, however, did ensure that liners and other engineering controls were used by the facility in constructing the pond. North Dakota is in the process of amending its solid waste regulations, which as proposed would require the permitting of surface impoundments used for coal gasification process wastewater storage and management. The extent and nature of any additional technical criteria applied to these units or to gasifier ash landfills, however, cannot be predicted. Finally, although North Dakota's air pollution control rules include provisions for control of particulate matter releases from industrial processes, the air permit for the Beulah facility does not directly address the facility's waste management units.

5.5 Waste Management Alternatives and Potential Utilization

As noted above, the available data indicate that gasifier ash and process wastewater do not exhibit any of the characteristics of hazardous waste. Consequently, the issue of how a gasification facility might modify its operations or waste management practices or be stimulated to develop alternative uses for the ash in response to prospective hazardous waste regulation is moot. Nevertheless, this section provides a brief summary of current coal gas waste management practices and potential areas of utilization.

Coal Gasification Process Wastewater

The process wastewater has an average pH of 9.8 with approximately 0.2 percent solids. Instead of being used as make-up water for the cooling system, the process wastewater could be treated and discharged, although the practicality of this option is limited because the facility is located in a water short area. In addition, the wastewater could be treated to remove contaminants prior to use in the cooling system. This approach would be less efficient than current practices, however, because the efficiency with which contaminants can be removed from the wastewater generally increases with increasing concentration, and use of the wastewater in the cooling system increases the contaminant concentrations through evaporation.

Coal Gasifier Ash

Although none of the ash currently being generated is sold for commercial use, ash with sufficient pozzolanic properties could be used in the manufacture of cement and concrete products. However, the levels of uranium-238 and other contaminants make it uncertain whether utilization of the ash in this fashion would be adequately protective of human health and the environment. In addition, utilization requires an available market and it is not clear that a significant market exists near enough to the facility to be economical.

Alternative approaches to disposal would include installation of a synthetic liner and leachate collection system in the on-site landfill and run-off pond.

5.6 Cost and Economic Impacts

Because the available data indicate that gasifier ash and process wastewater do not exhibit any of the characteristics of hazardous waste, the issues of how waste management costs might change because of new requirements associated with regulation as hazardous wastes under RCRA Subtitle C for these wastes and what impacts

such costs might impose upon affected facilities is moot. Consequently, no incremental costs or associated economic impacts would result from a decision to remove the mining waste exclusion for these wastes.

5.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For each special waste, these categories address the following three major topics: (1) potential for and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation.

Coal Gasifier Ash

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of coal gasifier ash is low to moderate as compared to other mineral processing wastes studied in this report. The ash does not exhibit any of the four characteristics of hazardous waste, and data on constituent concentrations in solid samples and laboratory leachate of the ash indicate that only two constituents are present in concentrations greater than 10 times the screening criteria used in this analysis. The ash, however, may contain uranium-238 and its decay products in concentrations that could pose an unacceptable radiation risk if the solids were allowed to be used in an unrestricted manner.

In addition to the relatively low to moderate intrinsic hazard of this waste, current management of the ash at the coal gasification facility in Beulah, North Dakota (the only facility addressed by this report) appears to limit the potential for the ash to threaten human health or the environment. Although there is the potential for release of constituents to ground water at the North Dakota facility, as evidenced by documented releases of contaminants to ground water underlying the ash landfill, the potential for significant risks resulting from drinking water exposure is low because of the relatively large distance from waste management units to potential exposure points. Similarly, threats to human health and the environment from releases to surface water are limited by the large distance to the nearest downgradient perennial streams and the relatively large flow of the Knife River. The release of contaminants to the atmosphere is limited by dust suppression measures at the landfill, and in any case, would pose a small risk because of the large distance to the nearest residence.

Environmental damages associated with the Dakota Gasification ash management facility have been documented by the State of North Dakota, and reveal that drainage from an ash landfill was observed to have pH values of 12.7 to 13.7, arsenic concentrations of 13.8 to 22.0 mg/L, and selenium concentrations of 1.1 to 2.2 mg/L. EPA believes, however, that these high levels are caused in large part by wastes other than the ash that were co-managed in the landfill, because leach test analyses of the ash by itself show significantly lower concentrations. In addition, as discussed above, the potential for significant exposures to this contamination appears low.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

The relatively low to moderate intrinsic hazard of the waste and the waste, management practices and environmental conditions that currently limit the potential for significant threats to human health and the environment are expected to continue in the future in the absence of more stringent federal regulation. The character of the ash is unlikely to change in the future, and despite the fact that the analysis of potential dangers is limited to the one active site at which the waste is currently managed, EPA believes that the conclusion of low hazard can be extrapolated into the future unless coal gasifier ash is managed in locations that are closer to potential exposure points. However, it is unlikely, for two reasons, that risks would occur at other locations in the future. First, without the kind of subsidy provided for the construction of the existing facility, it is unlikely that economic conditions would favor the construction and operation of new facilities in the near future. Second, gasifier ash is not currently used or disposed off-site, though

there is a slight possibility that ash with certain properties could be used at alternate sites in the future for the manufacture of cement and concrete products.

The potential for increased risks from gasifier ash management in the future is further restricted by substantial State regulation of the ash landfill. North Dakota's regulatory program excludes gasifier ash generated at the Beulah facility from hazardous waste regulation, addressing it instead as a "special waste" under the State's solid waste rules. Under this approach, North Dakota currently regulates the disposal of gasifier ash by requiring that the landfill into which the ash is placed be permitted. Permit requirements include standards for liners and closure. The State is currently in the process of amending its solid waste regulations, though the likely effects of these amendments on coal gasifier ash management and disposal are not clear.

Costs and Impacts of Subtitle C Regulation

Because of the low risk potential of gasifier ash, the general absence of documented damages associated with this material, and the fact that this waste does not exhibit any characteristics of hazardous waste, EPA has not estimated the costs and associated impacts of regulating gasifier ash from coal gasification under RCRA Subtitle C.

Coal Gasification Process Wastewater

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of coal gasification process wastewater is moderate compared to other mineral processing wastes studied in this report. The process wastewater does not exhibit any of the four characteristics of hazardous waste. Data on constituent concentrations in the wastewater, however, indicate that seven constituents are present in concentrations that exceed the screening criteria used in this analysis by at least a factor of 10.

Although the intrinsic hazard of this wastewater is moderate, current management of the wastewater at the Dakota Gasification facility in North Dakota appears to limit the potential for this waste to threaten human health or the environment. Releases from the surge pond to surface or ground waters are considered unlikely because of the pond's double synthetic liner, leachate collection systems, and run-off controls. In addition, any contaminants released by the volatilization, seepage, or run-off of the process wastewater would pose little risk because of the large distance to potential exposure points.

The lack of documented cases of damage attributed to coal gasification process wastewater confirms that the waste, as currently managed, appears not to cause significant health or environmental impacts. Review of State and EPA Regional files and interviews of State and EPA Regional regulatory staff did not produce any evidence of documented environmental damages attributable to management of process wastewater at the active Dakota Gasification facility and two inactive coal gasification facilities.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

The relatively low hazard posed by current management of coal gasification process wastewater is expected to continue in the future in the absence of Subtitle C regulation. The characteristics of this waste are unlikely to change in the future, and despite the fact that the analysis of potential dangers is limited to the Dakota Gasification facility, EPA believes that the conclusion of low hazard can be extrapolated into the future unless coal gasification process wastewater is managed in locations that are closer to potential exposure points or in ponds with less comprehensive release controls. However, it is unlikely that risks would occur at other locations in the future because construction of new gasification facilities is not foreseen and it is unlikely that the wastewater would be managed off-site.

The potential for increased risks from coal gasification process wastewater management in the future is further restricted by substantial State regulation of "special waste" management units. North Dakota's regulatory program excludes coal gasification process wastewater generated at the Beulah facility from hazardous waste regulation, addressing it instead as a "special waste" under the State's solid waste rules. The State has not required that the process wastewater ponds at this facility be permitted, though the State did ensure that liners and other engineered controls were

adopted in the construction of the surge pond. North Dakota is currently in the process of amending its solid waste regulations, which would require the permitting of process wastewater surge and cooling ponds, though the extent of permit requirements and their effect on the management and disposal of the wastewater is not clear.

Costs and Impacts of Subtitle C Regulation

Because of the low risk potential of process wastewater from coal gasification and the absence of documented damages associated with this material and the fact that this waste does not exhibit any characteristics of hazardous waste, EPA has not estimated the costs and associated impacts of regulating process wastewater from coal gasification under RCRA Subtitle C.